Wearable Computing: the Present and the Future

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Abstract: The concept of wearable computing is a natural reaction for the everyday people's needs. It requires a description of the interface that gives physical senses, communication, intellect and abstraction capacity from the user's point of view. This communication resumes the wearable designer's needs as they balance power requirements and network resources, presenting the possibilities wearable systems can offer.

1 Introduction

Today, computers go everywhere with the users. Devices, such mobile phone, laptops, palmtop, compact disk player, for every purpose from remote teleworking to anytime, anywhere e-mailing, are portable. But some of them are not small enough to be seamlessly wearable.

A wearable computer should be comfortable, intelligently and continuously. Mann Steve [1] describes the wearable like smart cloths.

Available wearable computers, such as Xybernaut's MA V and ViA's wearable computer and the research prototypes described in [2], [3] and [4] have the same architectural styles, but another architecture concept is under study at the Technische Universität München [5]. They all have the same requirements and objectives. It is the aim of this communication to briefly describe some of these technologies and give an indication of their current status. The communication starts by describing some available features in wearable computers. It will then go on to describe wearable design needs and current technologies. This is followed by a discussion on power requirements, and finally the main differences between the two architectures referred above.

2 What is a Wearable Computer

A wearable computer is a system that is always with the user, is comfortable and easy to keep and use, and is as unobtrusive as clothing; however, this definition is too vague. A more specific definition is that wearable computers have many of the following features:

- **Mobile:** where the users go it goes, like the user cloths, always with user and always doing its job. This distinguishes wearable from the desktop and laptop computers, but does not distinguish from portable phones.
- **Persistent:** always on and always working, sensing and acting. This is opposed to the normal use of personal digital assistants (PDAs), which normally sit in one's pocket and are only switched on when a task needs to be done.

- **Enable hands-free, eyes free and brain free:** these demands are required by wearable and achieved reducing the user time and attention. Wearable helps the user in the daily tasks, being part of the solution, avoid distracting him. Wearable might use chording-keyboards, dials, and joystick to minimize the tying up of user's hands. Other applications use context based information provided by sensor, preventing the use of direct input by the user, but are guided by the environment.
- **Proactive:** wearable applications are capable of taking action to get the user's attention. For example, if the computer wants to let know that the user have an important call, or email and who it is from, it should be able to pass this information to the user immediately.
- **Context aware:** a wearable knows something about the context of the user and can change its behaviour or take action on the user's behalf based on the context. In addition to normal user-inputs, a wearable should have sensors for the physical environment.

These attributes should be interpreted as guidelines rather than absolute. In particular, good wearable computing design depends greatly on the particular applications intended for the device.

3 Wearable Capabilities and Applications

Some businessmen wear too many computers like a PDA, a cellular telephone, a pager, a laptop computer, an electronic translator and a calculator. All these devices contain very similar components: a microprocessor, memory, a screen, a keyboard or other input devices, a battery, and in some cases a wireless modem. So what kinds of applications will be offered when all these devices disappear into the smart clothing? As the processing power increases and the machines get smaller, the application will be limited only by the quality of the sensory, battery, input and output and available networking capability. Consider the following applications:

- **Proactive monitoring:** with sensory devices that can monitor body vital signs, wearable can be a powerful personal health monitor. The wearable can collate on a regular basis, pass it on for processing and ensure that any symptoms that can lead to some medical condition can track or identify at an early stage.
- **Augmented reality:** with the wearable position knowledge, it is well placed to have applications that use the real world as part of their interface. For example museum visitors and tourists will discover information about artefacts simply by staring in front of them, triggering associated hypertext presentations. Another example: friends and colleagues will be able to leave private messages for each other at the offices, restaurants, coffees, or street corners.
- **Augmented intelligence:** there are a range of data capture devices that can gather information about the environment and activities. Context-sensitive interfaces will become very powerful with the wearable computers. This contextual information can be used by a host of applications. Such reminders might be the definition of unknown word, or the shortest path to home, and, if alone, the appropriate remember can be the friend's birthdays remember.

- **Remote intelligence:** With improvements in radio networks and bandwidth limitations reduced, will be possible to observe groups interacting naturally wherever their physical location.

Wearable computers give the opportunity to bring new sensors and technology capable to produce an interface appropriate for the user abilities. So pieces of physical context information can be used by the wearable computer to provide constant support to users and to be able to adapt the computer to user needs and user access permission.

4 Devices and Design Requirements for Wearable

Most of the design requirements for portables no longer apply in the wearable-computing environment. The most immediately noticeable issues to provide wearable computing will be mentioned below. However, the most significant framework in design wearable computers is creating appropriate interfaces.

4.1 Input Devices

Traditional keyboards as input devices are against the wearable characteristics, they rely on a steady surface and cannot be effectively used while walking. Traditional keyboards are too large to be portable, to be hidden from view or to be kept unobtrusive, which is important in many social situations.

Wearable input needs are carrying out by a whole range of hand keyboards offered in market. Witch keyboard have a function and design that adapts to the situation user's requirements.

The following input devices are all possible solutions for wearable input devices; they are small and can fit on a pocket.

Fig.1. Input devices.[1]

4.2 Output Devices

A little display makes a big difference. An example of a small head-mounted display is the MicroOptical AV-1, see Fig.2.

[1] Images were gently provided by Handykey Corporation, Universidad Nacional Autónoma de México, L3 Systems, Tactex, Senseboard Technologies, Kord Interface Technology and Essential Reality.

Fig. 2. Model AV-1 QVGA ASCII Viewer (320x240pixels)[2]

The Microvision Company offers a several displays products for each job and life style application.

Fig. 3. Various Display Products [2]

Because audio does not detract the user in the same way as a screen or display interface, audio output is especially useful where the user is driving, involved in delicate operations, or may be blind. Audio is also particularly useful for conveying peripheral information.

At the Universal Display Corporation a paper-thin display named FOLED (Flexible Organic Light Emitting Device) offers revolutionary features for displays (Fig. 4 shows an example).

Fig. 4. FOLED [2]

[2] Images were gently provided by MicroOptical Corporation, Microvision and Universal Display Corporation.

4.3 Environment sensors

One key benefit of wearable computers will be their ability to make immediate environment in the wearable applications. The wearable applications need some way of sensing the environment and users position within that environment. Crude position location can be achieved outside with GPS system together with speed and direction. As soon as the user moves inside a building the problem becomes more difficult. Buildings have to be adorned with some kind of location beacons that can be picked up by the wearable. However the wearable user could manually update his position. Position is only one factor of potential sensors on a wearable. Simple sensors that measure temperature, humidity, noise levels, light levels or movement are also available, combined with image and voice recognition systems these can provide an excellent basis to model the user's environment that can provide cues for context-based applications.

4.4 Networking

For wearable computers, networking involves communication off wearable to the fixed network, on body among devices, and with objects near the user. Each of these three network types requires different design decisions:

- **Wearable and fixed network:** The Global System for Mobile communications (GSM), General Packet Radio Standard (GPRS) and Universal Mobile Telecommunication System (UMTS) can help in this problem. But users will always face situations in which mobile devices will not be on the range of network cell or it will be unprofitable to provide coverage for some areas. For indoor use wireless Land or LEC is appropriate.
- **Interoperability:** A user should be able to place various devices on their body and have all networks together to provide distributed functionality. In addition, the devices should be able to query each other to see what functionality they have for input and output, so the best interface can be assembled on the fly. For example, if the user has a PDA and a cell phone, then while he is using the PDA any calls received on the phone should be shown on the PDA screen. This type of networking encompasses the Bluetooth standard for ad-hoc networking, but moves beyond it by providing interface query functionality. With this type of network capability, distributed wearable systems could be assembled out of the various consumer electronics devices the user is already familiar with.
- **Communicating with near-body object:** An example for the near-body object communication necessity is the Locust position system. The Locust's primaries propose is to provide location information inside the building. Each Locust consists of a micro controller, infrared transmitter and infrared receiver. The infrared transmitter repeats a unique ID every second with an offset determine by its ID to avoid repeated collisions with other Locust. By listen this ID and having a correspondent map of the area, wearable computers can determine their location.

5 Power Requirements

Power consumption provides a significant limitation to the application of wearable computing. More disk and processing power consumes more power, as network

connectivity does and to a lesser extent: the type of sensors used on the wearable. The table below shows comparative power consumption for several processor architectures:

Table 1. Processor Power consumption

Processor	Power (watts)
TM5800 Crusoe ^{TM} (367 – 800 MHz)	0,4 – 1 W
Intel® StrongARM SA-1110 (133MHz, 206 MHz)	240mW- 400mW

Environmental energy sources can begin to replace batteries in certain wearable subsystems. The MIT Media Laboratory develops a parasitic power harvesting in shoes project, shown in Fig. 4, which is taken from [6]. This project describes the available and implemented solutions for extracting power from foot pressure.

Fig. 5. Parasitic power harvesting in shoes project.

All the choices of display, input device, networking, processing and power requirements become clearer for wearable definition.

6 Architecture concepts

In the market: Xybernaut's MA V and ViA's wearable computer; and researches [2], [3] and [4], wearable computer have a similar architecture that a personal computer. They use a CPU as the core of wearable, which controls the entire functionality. Other devices are peripherals that are connected by an interface, for example the Georgia Tech Wearable Motherboard (GTWM) [7], to the CPU. The software that makes the peripheral devices useful runs on the CPU not in the peripheral device. The Technische Universität München [5] introduced another concept, based on the ubiquitous computing. A wearable computer is composed of a network of modules. Each of them is a hardware unit with its own processing unit, memory, I/O, power, and network connection, and provides specific functionally in the network. Hardware modules are used the same way that software components in distributed component-based systems. This concept has been used in the DWARF framework a prototype system for indoor and outdoor [5].

Placing these two concepts together will end on the future of wearable computers (like the first concept) and the other wearable complementary devices (second concept).

7 Conclusions

Wearable computers are private and more discreet in many situations than consumer devices as cellular phone, pagers or PDAs. The user can concentrate on physical reality but have immediate access to the virtual if needed.

The user grows to expect his interface to be accessible continually and unchanging, unless specified otherwise.

Wearable computing provides a truly digital assistant. Building an effective computing system needs careful consideration from display technology, input and sensing devices.

It is not difficult to see that wearable computer concept and integral definition is technical feasible.

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